LESSON 22 – TARGET RESOLUTION
(Application Exercise 2 Due)
"Cougar, I'm going to break high right to see if there's a trailer…" So how do we know whether that blip is more than one enemy?

Reading:
Stimson **Ch. 7, Ch. 8**
Problems/Questions:
Finish Application Exercise 2, Work on Problem Set 3
Objectives:
22-1 Be able to describe several reasons why radars use certain frequencies.
22-2 Know the reason why radars have a main lobe and side lobes.
22-3 Know how a radar's beam width is defined.
22-4 Understand how angular resolution is determined.
22-5 Know the factors that degrade angular resolution.
22-6 Know the factors that enhance angular resolution.
22-7 Understand antenna gain.

Last Time: Phasors/Computer Application

Today: Angular Resolution

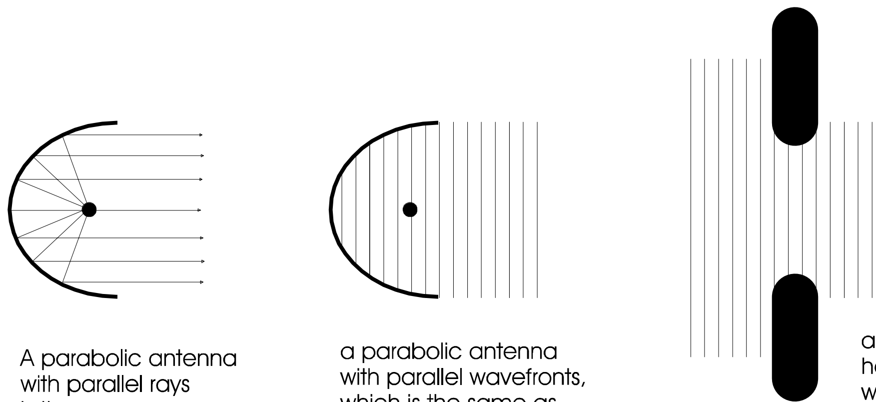
Go over computer application

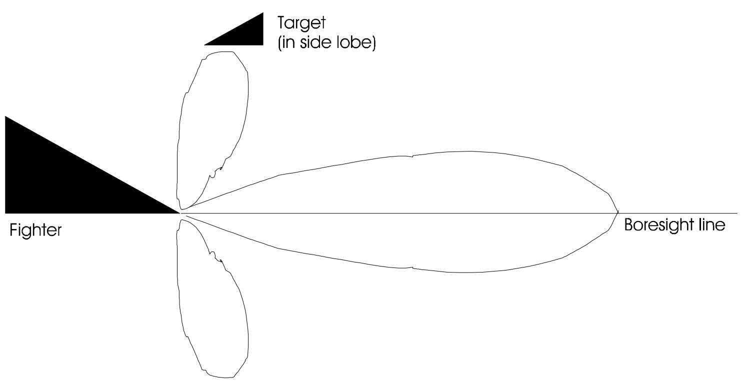
Show a 1" toy airplane and have the cadets point at it. Go over how they did it
- their eyes found it (angular position)
- their eyes focused it (range position)
- sensors in their eye muscles told their brain where the eye was pointing
- the brain told their hand where to point

This is a good analogy to radar: The antenna seeks and finds, servo positions tell the computer where the antenna is pointed, the computer tells the screen where to put the blip.

Locate a second toy airplane, but this time only allow the cadets to look through a tube. Let this exercise be an introduction to scan patterns, advantages/disadvantages of small beamwidths. Explain that a radar returns a target/no target answer each time a pulse is sent out.

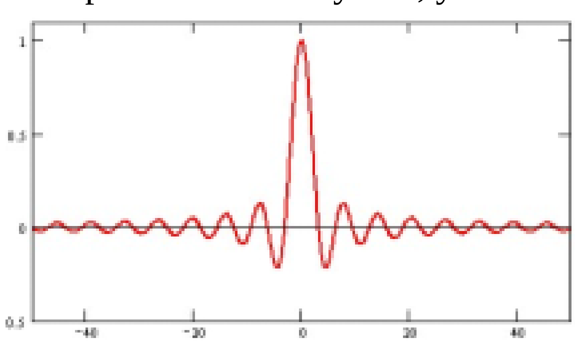
Switch gears to diffraction. Show Mechanical Universe 40:31734 (waves diffracting through a slit). Show how this is the same as a parallel set of rays exiting a parabolic dish.



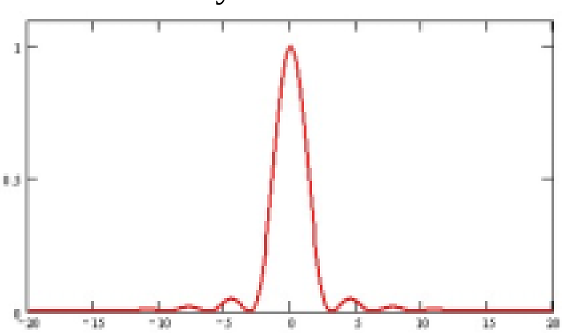


Diffraction causes the beam to spread out. Is this bad? Yes, for several reasons. Show that the target/no target answer could be affected by a target in a sidelobe.

How does the beam spread? From Phy 215, you saw that the intensity pattern looked like [sin(x)/x]2. Draw both sin(x)/x and its square on the board.



sin(x)/x



$[\sin(x)/x]^2$

Show a laser through a single slit demo.

From Phy 215, you saw that the dark spots occur at $\sin(\theta) = m(\lambda/a)$ where m = ±1, ±2, ±3… and a = the slit width and λ = the wavelength.

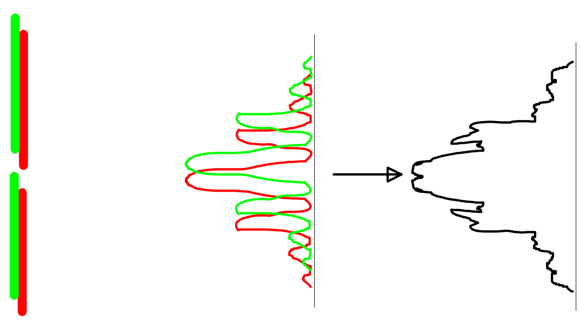
So what do we want? θ = big or small? Small, of course! Small angles mean a more precise target locating ability. This means we want a small wavelength and a big antenna so that our beamwidth is as small as possible.

Show overhead of slide from Jenkins and White, p. 334-335 & discuss loudspeaker diffraction for concerts (the typical speaker setup puts all the noise in a small vertical space and a large horizontal space).

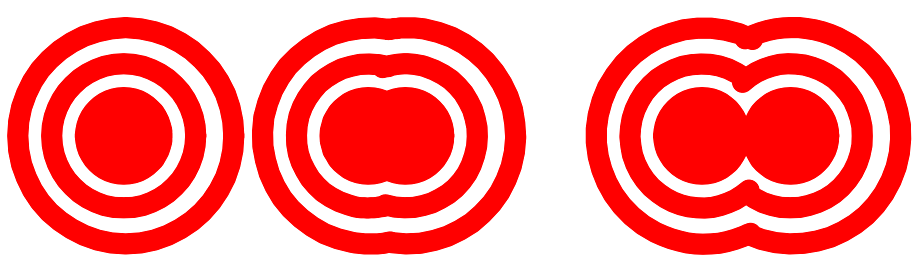
Discuss constraints upon λ and a in fighter radars. (Size and atmospheric attenuation).

Draw two overlapping slits and their circular diffraction patterns. Imagine each slit is a target. How do we know whether we have one or two targets? Only when they are separated far enough that we can tell that there's some space between the two targets, otherwise it could be a single, large, irregular target.

Show resolution.avi.



In 215, we used the Rayleigh Criteria for resolution. This, for circular slits, is $\theta_m = 1.22\ \lambda/D$



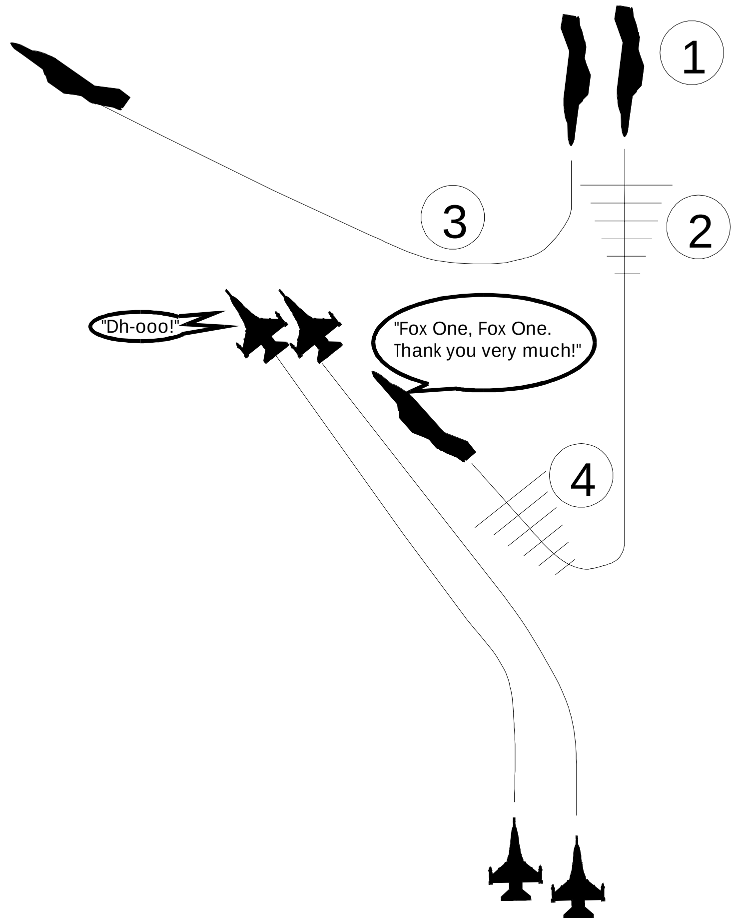
For this class, we'll use the 3dB power criteria, which is very similar. $\theta_{3dB} = 1.02\ \lambda/D$.

Note that for all of these cases, resolution is related to the ratio of wavelength to slit size (either a or D).

What is 3dB? A QUICK rundown of dB. dB is a ratio of powers. When we say what is the 3dB power, we really mean what is the ratio of the power at the 3dB point to the power at the maximum of the curve. By definition, x dB = $10^{x/10}$. So 3 dB = $P_{\theta=3dB}/P_{\theta=0} = 10^{3/10} = 2$. The 3 dB point is just the angle where the power of the signal has dropped to half of its maximum.

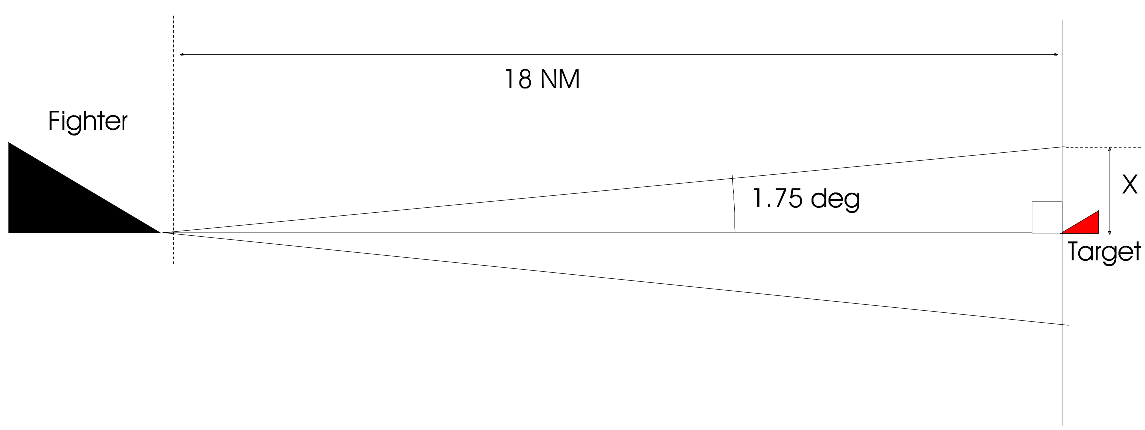
So what is θ_{3dB} for our radar? θ_{3dB} = 1.02 (3cm/1m) = .0306 rad = 1.75 deg

Discuss a res-cell intercept, emphasizing diffraction/beamwidth, Doppler notch, and low wingman SA on the Viper team. Briefly show how an intercept such as this was designed by someone with an in-depth knowledge of his radar and the adversary's radar.



Go back to the res-cell tactics discussed earlier. Recall that at 20 NM you needed to make a commit/disengage decision else you could quickly become a mort.

tan 1.75 = x/20NM => x = 0.61 NM = 3700'.



This says that if you are flying within 3700 feet of your wingman, a radar with a 10GHz frequency and a 1 m dish WON'T be able to tell if you're a singleton or a pair.

Show hallway demo. At that scale, the crosshall is about 20 NM long. A single 1" airplane placed in the center of one pane of glass at the far end of the hallway will be a scale ½ mile from a pair of fingertip targets placed in the center of the adjacent pane of glass. From 20 NM, your eye can see both targets, but a radar would just say "target," not knowing how many were actually there.

Why can your eye see the targets? Do the math. D = 1mm, λ = 500nm

$\theta_{3dB} = 1.02\ \lambda/D = 1.02(500 \times 10^{-9} m/1 \times 10^{-3}\ m) = 5.1 \times 10^{-4}$ rad $= 2.9 \times 10^{-2}$ deg

At 18 NM, $\tan(2.9 \times 10^{-2}) = x/18$ NM, so $x = 9.2 \times 10^{-3}$ NM = 56', or about one ship length resolution for your eye.

But 3700' feet is a HUGE space. I told you that we typically flew wingtip overlap to beat the Vipers. Why? A partial answer to this comes from the second of the three dimensions of a res cell – range (the third dimension is velocity). You need to read Hughes, chapter 9 to understand this, and you need to understand this to be able to finish the problem set that's due in a couple of lessons…